Appendix F

Report on Fire and Post-Fire Management Effects

Report on Fire and Post-Fire Management Effects - Butte Falls Resource Area

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I. Introduction and purpose

Frequent forest fires are part of southwestern Oregon ecosystems and have been a persistent disturbance in this region for perhaps tens of thousands of years. Historically, fires were viewed as disasters and were aggressively fought over the last 50 years. These fire suppression activities resulted in reduced extent of fire and increased fuel loadings. Today, knowledgeable citizens, managers, and scientists view fire as an essential component of functioning ecosystems and regard management of fuel loads as critical for community and rural residents' safety and for reducing fire severity.

In 2002, the largest wildfires in the state's recorded history prompted widespread interest in forest and fuel management effects on fire behavior and severity, the effects of fire on many ecological and social systems, and on the efficacy and wisdom of post-fire management activities. It was quickly recognized that the fires of 2002 provided a unique opportunity to learn more about these issues. A science team organized by the Cooperative Forest Ecosystem Research (CFER) program and composed of scientists from Oregon State University (OSU), the U.S. Forest Service Pacific Northwest (PNW) Research Station, the Bureau of Land Management (BLM), and the US Geological Survey (USGS) engaged in a series of activities during the winter of 2002/2003 to better understand information needs of managers and to suggest adaptive management approaches to pre-fire, fire, and post-fire management activities. The specific objectives of these activities were to:

1. identify important management and science fire-related questions worthy of further study
2. help shape study proposals to address these questions
3. provide information to the BLM to help the agency conduct post-fire planning, implementation, and monitoring
4. identify potential components of alternatives focused on learning objectives and adaptive management for post-fire management activities
5. build relationships among scientists and BLM managers interested in fire-related research in southwestern Oregon

This paper reports on the outcome of these efforts. Findings discussed here are simply a collection of observations based on our field review of fires on the Butte Falls Resource Area, our experiences elsewhere, and our knowledge of the current literature. The intent was to help sort issues and suggest ways to expand our knowledge, and we strongly suggest that use of our findings should keep the context of the observations in mind.

II. Methods

A science team based in Corvallis (see Appendix A for team composition) interacted with members of the Medford BLM District in two extended field visits. First, the team visited the Medford District in December 2002 to interact with approximately 45 forest managers and identify important management and research questions related to fire. The team spent a day in the field touring a recent large fire (the

Timbered Rock Fire, 2002) and learning about management concerns. The team and managers spent the following morning in a "brainstorming" session to discuss and identify priorities for management and science questions of interest.

Members of the science team returned to the Medford District in January 2003 to observe existing conditions at several previously burned sites on the Butte Falls Resource Area. The team spent two days in the field visiting five fires (Grave Creek, Sykes Creek, East Evans Creek, Hull Mountain, and Timbered Rock) that burned from 1978 to 2002. The team then participated in a half-day meeting with approximately 40 personnel from the Medford District to share observations and discuss limitations of existing knowledge concerning fire and post-fire management effects.

III. Post-fire management issues and discussion

Based on field observations, expert opinion, and knowledge of the current literature, the science team provided their opinions and observations on several issues related to post-fire management activities. These observations are summarized below with the acknowledgement of the general context in which they were given.

A. Are there likely to be significant soil compaction effects if areas are salvage logged?

Discussion:

As with any timber harvest activities, soil compaction could arise during fire-salvage operations. For standard logging systems, compaction is primarily limited to skid trails or possibly yarding corridors in cable logging operations. Site-specific conditions and harvest practices will strongly influence the magnitude and duration of compaction effects. Compaction could result in increased storm runoff in localized areas. Because of the potential for increased erosion and runoff in a post-fire environment, compaction effects could be more significant than in unburned areas.

Science status:

Many studies have shown soil compaction and reductions in nearby tree growth resulting from repeated passes of ground-based logging equipment, although significant areas of uncertainty remain. For example, the duration of compaction effects and whether compaction reduces stand growth are not well understood. The USDA Forest Service is participating in at least two long-term, site-productivity experiments addressing these questions. Although it may take decades before answers are forthcoming from these studies, results are available from a recent study conducted on the Willamette National Forest (Young Stand Thinning and Diversity Study) that evaluated the effects of several commercial thinning prescriptions and logging systems on soil compaction.

Summary:

Soil compaction is an important issue that merits attention when implementing salvage-logging practices. Careful design of logging practices and mitigation measures can minimize effects. Implementation monitoring is critical to adaptive management for soil compaction issues.

B. What is the extent of hydrophobic soils following fires, and does this condition merit treatment?

Discussion:

Although hydrophobic soils can result from high-severity fires, observations suggest that such soils are generally a small and transitory component of burned landscapes, and of more significance in other regions where coarse-grained soils predominate. Hydrophobic soils tend to physically break down once significant precipitation occurs. Little evidence exists of lasting ecological effects. Mechanical treatments to “break up” hydrophobic soils may not achieve ecological objectives and may lead to reduced site productivity and increased erosion.

Science status:

Little is known about hydrophobic soils resulting from fire in southwestern Oregon. Hydrologic studies following the 1987 Angel Fire in southwestern Oregon suggested minimal occurrence of water repellency over a limited range of burn conditions. New studies could be established to better understand the extent, magnitude, duration, or effect of hydrophobic soils across a broader range of burn conditions for different soil types in the Timbered Rock Fire.

Summary:

The limited spatial and temporal extent of hydrophobic soils may not merit significant investment of time and limited resources for management activities in the post-fire environment, but studies could be initiated to better understand the occurrence of hydrophobic soils and the potential effects at the watershed scale.

C. Should grass seed or other mitigation measures on burned areas be applied to reduce surface erosion?

Discussion:

In general, the most important activity to minimize surface erosion from burned forests is tree and shrub establishment. The contributions made by sprouting hardwoods, including shrubs, may be more important than planting conifers, especially in the short term. Little documentation from monitoring mulching and baling (bale bombing) activities exists, but observational and anecdotal evidence indicate that such activities may not significantly reduce surface erosion over the broad landscape. Highly disturbed and sensitive areas may benefit from grass seeding where high short-term risks exist and where grass can be established before potential erosional events. Similarly, contour felling to reduce erosion may be effective in small localized areas where highly erosive soils and high ecological values exist, but little evidence indicates it is an effective landscape treatment.

In most cases, seeded grasses will not persist where trees are re-established following fire. Tree shade will quickly reduce the extent of grass cover. When seed is applied, there is always risk of introducing exotic plants or noxious weeds that may persist in disturbed, open areas, such as along roads. Also, “weed-free” seed often contains a small percentage of weedy seed. There are many cases where unwanted exotics and weeds have been unwittingly introduced.

Science status:

Grass seeding and other mitigation measures are part of a standard toolbox for post-fire rehabilitation, but little formal evaluation of the effectiveness of these approaches has been conducted. Small-scale studies have been conducted in southwestern Oregon following the fires of 1987 and a large-scale evaluation of the Hayman Fire in Colorado is underway. The extensive fires in southwestern Oregon in 2002 may provide a basis for a regional study of the effectiveness of these approaches. At the local level, implementation and observational effectiveness monitoring should be part of any mitigation measures intended to reduce surface erosion.

Summary:

Although evidence suggests that measures intended to reduce surface erosion are not effective at a landscape scale, site-specific measures (i.e., grass seeding, contour felling) may be effective on highly sensitive sites where ecological values are high. A comprehensive evaluation of these measures at spatial scales ranging from local to regional could be valuable.

D. Does timber salvage lead to increased erosion?

Discussion:

The effects of timber salvage on erosion are primarily limited to surface erosion, unless the salvage activity includes substantial levels of green tree harvest. Tree roots hold soil on steep slopes reducing the extent of mass movements, but roots of fire-killed trees likely decompose on the same trajectory whether or not the tree bole is harvested. Surface erosion can occur from salvage harvesting similar to any harvest activity that includes road construction, skid roads, or yarding corridors. Site-specific conditions and harvest practices will strongly influence the magnitude and duration of surface erosion. Mitigation measures have been developed to reduce erosion, and many of these measures have been integrated into standard harvest practices. When the extent of the burned area is large, downslope effects from erosion may be more significant than in unburned areas.

Science status:

There is strong evidence that erosion from salvage logging can result in negative cumulative effects in a post-fire environment. In areas where salvage logging is conducted, surface erosion mitigation measures should be implemented to minimize erosion. Although general surface erosion mitigation measures for standard timber sales are well known and applicable to salvage harvests, little direct monitoring of surface erosion from timber salvage in southwestern Oregon has been documented. We suggest implementation monitoring of prescribed mitigation measures and documentation of the effectiveness of these measures.

Summary:

Surface erosion from roads and skid trails used for salvage logging does occur, and every effort should be taken to minimize erosion in post-fire landscapes. Prevention and mitigation measures can be applied to minimize erosion and should be monitored.

E. Have fires and post-fire salvage activities increased stream temperatures?

Discussion:

Stream temperatures may rise from reduced shading due to fire-induced mortality of riparian vegetation. The significance of increased heat energy reaching the stream changes from stream-to-stream depending on stream orientation, influence of ground water sources and hyporheic flows, and the vigor of streamside shrubs. For example, warming through direct solar radiation may persist downstream as the stream passes through additional shade-free areas or may be insignificant where cool groundwater and hyporheic flows control stream temperature. Streamside buffers left during salvage activities can maintain the partial shade provided by snags. If timber salvage includes harvest of green trees currently shading perennial streams, stream temperatures could significantly increase. Harvest of fire-killed trees that currently shade streams also could increase the heat energy reaching the stream surface, although not to the degree associated with harvesting of green trees.

Science status:

Understanding the factors controlling stream temperature, including the influence of management activities, is a topic of ongoing research. Current work is aimed at examining the influence on stream temperatures of groundwater and hyporheic flows as well as streamside vegetation. Studies could be implemented to evaluate the degree of shading provided by alternative riparian buffers in timber salvage operations. Current research is aimed towards development of models that predict the influence of alternative harvest practices across a wide range of potential treatments based on fundamental ecological processes, but there is a critical need for information concerning the watershed-scale influence of site-level temperature changes.

Summary:

Increases in stream temperature following fire may be significant depending on fire severity, slope, aspect, elevation, the influence of groundwater inputs, stream location within the stream network, and other factors. Retention of streamside buffers during salvage activities minimizes the effects of salvage logging. Studies could be implemented to better document the effect of fires and timber salvage on stream temperature, but current studies and modeling efforts may provide the information needed to predict stream temperature responses to future fires. Temperature monitoring at a variety of spatial scales (i.e., local to watershed) could provide important information concerning the effects of salvage logging procedures and practices.

F. Do fires influence stream channel morphology, and are there rehabilitation measures that can mitigate these effects?

Discussion:

Fires can and do influence stream channel morphology through potential increases in stream discharge or through introduction of sediment and channel forming materials from erosion. The key consideration is whether the stream channel has sufficient structure to capture and arrange these materials to form complex habitats. Many streams in this area have been eroded to bedrock, primarily through splash dam logging in the first half of the last century. In some streams, large numbers of additional wood pieces or large boulders are needed to influence the routing and storage of large sediment. Where roads adjoin streams, felling roadside hazard trees into streams can be done to increase channel structure. Adding logs with rootwads can greatly reduce log travel distance if downstream structures are vulnerable (i.e., buildings, bridges). Other sources of wood are abundant on the landscape.

Science status:

Many in-stream restoration projects have been completed in the last two decades; however, very few have completed long-term monitoring. One of the longer running studies in western Oregon was installed on a tributary of the McKenzie River in 1986. Significant local increases in channel and habitat complexity, litter retention, and juvenile trout recruitment have been documented. An important limitation of this study and other restoration monitoring projects is that the spatial scale is restricted to an individual stream reach or two. Fish populations respond at much larger scales. More comprehensive studies at larger scales are needed to better understand fish population responses to in-stream restoration.

Another aspect of this study was a comparison of log movement among unanchored logs, logs anchored at one end, and logs anchored at both ends. Log movement was tracked over time and reevaluated after a major flood event (February 1996). No difference was found in the proportion of logs moved (anchored vs. nonanchored), but anchored logs moved shorter distances. A large trash rack was installed downstream of the wood introduction to protect a bridge, but was taken out after 10 years because of the limited movement of large wood.

Summary:

Channel morphology may change in response to fires. Channel forming structure is needed in streams to create complex habitats by influencing stream flow and coarse sediment input. In some cases it may be necessary to add wood (i.e., felling trees into the channel) to encourage accumulation of wood and sediment following fire. Large-scale monitoring of post-fire channel morphology and fish population response is needed.

G. Is large wood located on potentially unstable upland sites important for slope stability and stream channel inputs?

Discussion:

Salvage logging of unstable sites may not affect the probability of mass movements because there is little difference in root decay of standing dead trees versus stumps. It is possible, however, for poorly designed logging operations to destabilize slopes, particularly through road construction or maintenance activities.

The more important factor for many sites is the potential for landslides and other mass movements from upland areas to provide large wood and coarse sediment to streams. Mass movements are critical to channel structure-forming processes and provide the materials essential for creating complex stream habitats in the long term. If large trees are left on unstable slopes in burned areas or large trees are encouraged to develop from younger stands on these sites, the resulting large wood could contribute to stream channel structure when mass movements occur.

Science status:

Recent science has clearly demonstrated the role of unstable upland sites in providing large wood and coarse sediment to streams in the Coast Range. Although these processes occur in the Cascade Range, their relative importance is not clear and is a subject of ongoing investigation. Field mapping and long-term monitoring of unstable slopes within a recently burned area could increase our knowledge of the frequency and significance of mass movements of large wood and coarse sediment to streams from upland sources.

Summary:

Development and maintenance of large wood on unstable slopes ensures that large wood delivery to streams will occur during mass movements. Field mapping and monitoring of these sites can provide useful information.

H. Are there specific post-fire watershed restoration activities that are both effective and important for watershed processes and aquatic habitats?

Discussion:

Roads alter several important watershed processes. Roads and culverts can impede fish movement, convert subsurface water flows to surface flows, contribute chronic fine sediment to streams, and initiate mass movements laden with fine sediment. Consideration of reducing the impact of roads is appropriate during post-fire recovery planning. There is high variability in the risk individual roads pose, and each road needs to be assessed independently and in the context of the watershed as a whole. Restoration measures include sidecast pullback, waterbar placement, culvert excavation and stream channel restoration, or replacing older culverts with a variety of contemporary stream crossings that allow passage of aquatic vertebrates. Each of these measures can be effective if properly designed for the local situation and management objectives.

Science status:

Few watershed restoration measures have incorporated long-term monitoring. A limited effectiveness monitoring project in the McKenzie River watershed showed that following culvert excavation on two road segments, stream channels were re-established that approximated pre-road stream gradients. Opportunities for designed studies comparing alternative restoration techniques exist.

Summary:

Improving road conditions can be one of the more effective approaches to restoring watershed functions. Individual roads should be assessed to determine their relative influence on watershed processes and the most effective technique for reducing their impact; however, restoring connections within the stream network by renovating culverts and other road crossings may be the most effective restoration measure taken in many watersheds. Long-term monitoring of restoration methods is needed.

I. Is there any increase in stream discharge due to fires, and would timber salvage have any additional influence on discharge?

Discussion:

The primary mechanisms for increased stream discharge in a watershed are increased ground water due to decreased evapotranspiration, increased snow accumulation and melt from rain-on-snow events, and conversion of subsurface flow to surface flow due to mid-slope roads. The importance of each mechanism varies by watershed depending on soil depth, elevation, site productivity, and other factors. Water yield increases are directly related to the mortality of vegetation. Fire can decrease evapotranspiration if mortality is high and productivity is low, potentially increasing discharge in a burned area. Yield will likely increase in the short term, but as vegetation is reestablished, yield will decrease. If salvage logging does not kill additional trees, salvage activities probably will not influence discharge levels. Most of the fires observed by the science team were below the transient snow zone, and snow pack hydrology may not be influential in these areas. Fire does not affect road density, but if mid-slope roads are built to facilitate salvage operations, discharge could increase due to this mechanism.

Science status:

The basic mechanisms by which forest management activities affect stream discharge have been studied for decades and are generally known; however, the degree to which these mechanisms operate in any given watershed varies. These mechanisms have not been studied in post-fire environments in western Oregon. Assessing the influence of management activities on stream discharge has proven notoriously difficult and expensive and is a long-term proposition. This is not likely to be a fruitful avenue for study at a project scale.

Summary:

Until forest canopy cover is re-established, water yield may increase following fire due to decreased evapotranspiration. Timber salvage is not likely to affect water yield unless new mid-slope roads are built or significant numbers of green trees are included in the harvest. The presence of woody debris, both on the ground and in the stream, can have an important influence on the hydrological effects of increased water yield, however.

J. What are the risks of noxious weed invasion following fire, and what management activities might retard or accelerate weed invasion?

Discussion:

There is almost always potential for weed invasion in disturbed areas if an environmentally adapted seed source is available. Attention should be paid to potential weed invasion after recent large-scale disturbances, such as burns. In most cases, noxious weeds will be shaded out as canopy cover re-establishes following fire. The presence of woody sprouting species may benefit many sites by rapidly reoccupying the site. Other areas that persist as “openings”, such as roads or meadows, may need more active management to minimize noxious weed establishment. It may be desirable to seed native grasses on certain sensitive sites to occupy the ecological niche and preempt weed invasion (e.g., disturbed areas that are close to a weed seed source and lack sprouting vegetation). Roads are potential dispersal pathways for many weeds and may need special attention if adjacent to sensitive sites.

Many management activities, including those intended for watershed restoration, could accelerate weed invasion, particularly through seed dispersal on vehicles or equipment. Mitigation measures, such as washing vehicles and equipment prior to entering the site, can minimize invasion risk.

Science status:

Basic research is needed on individual weed species ecology and effective invasion prevention and treatment methods. Current research is trying to link geographic spread and demographic models so that potential weed dispersal patterns can be predicted and potentially prevented where warranted. These are regional issues needing regional attention. However, monitoring is a critical activity at the scale of an individual fire. Burned areas should be monitored to determine if weed invasion is occurring. Management activities should be monitored to verify that mitigation measures are being applied and are effective.

Summary:

Weed invasion could occur following fire. Seeding with native species to prevent invasion may be warranted on sensitive sites, but the potential for introduction of non-native species from contaminated seed sources is a significant concern. Implementation and effectiveness monitoring are critical activities.

K. How does salvage logging affect future fuel loadings?

Discussion:

Salvage logging removes dead and dying trees, thus reducing large fuels in both the short and long term. Salvage logging also creates fine and mid-size fuels by leaving treetops, branches, and needles on site, thus increasing fuels in these size classes in the short term. Fine and mid-size surface fuels also occur in unsalvaged areas, but accumulate gradually over a couple of decades. It is unlikely that these fuels would reach the same magnitude as in the post-salvage scenario because decomposition occurs as new material accumulates.

The effect of surface fuels on fire behavior is complex. Flame length and fire spread is correlated with fine and mid-sized fuels, while fire duration and thus soil heating and plant injury or death may be more closely correlated with large fuels. Thus, salvage logging could increase the risk of fire spread in the short term while decreasing fire intensity and severity in both the short and long term. Thresholds defining when fuel profiles and fire intensity result in significant negative ecological effects (e.g., declines in long-term soil productivity) have not been determined. These interactions vary depending on snag falldown rates and decomposition rates of specific species and sites.

Science status:

Quantitative data describing falldown and decomposition rates of snags on salvaged and unsalvaged burned sites in southwestern Oregon have not been compiled. Several of the science team members submitted a proposal to the Joint Fire Sciences Program in January 2003 to address this and other information gaps through a retrospective examination of older fires in southwestern Oregon. A second step included in the proposal was to use this information to model fire behavior in salvaged and unsalvaged areas to estimate effects of various fuel profiles on fire extent and severity.

Summary:

Salvage logging undoubtedly affects fuel profiles in complex ways, but the data and analyses necessary to make conclusive statements about the net effect of these changes on future fire extent and severity have not been conducted.

L. Is herbaceous species diversity higher in salvaged or unsalvaged areas?

Discussion:

Some studies in disturbed areas have shown initial increases in plant diversity due to establishment of exotic plants, followed by a decrease in diversity with canopy closure. A more important question might be whether herbaceous species are lost in salvaged areas. Species loss is very difficult to determine because rare species, which are most likely to be lost from a site, are very difficult to monitor. Information sufficient to answer this question has not been obtained to date. Another, potentially more relevant question, concerns the effects of salvage logging on epiphytic lichens, bryophytes, and fungi, particularly those which disperse very slowly into new habitats.

Science status:

Most herbaceous species can be readily monitored to determine the effects of salvage logging on species richness and abundance. Replicated monitoring plots could be established within the salvaged and unsalvaged areas. Long-term studies may be needed to assess effects on rare species.

Summary:

Monitoring plots could be established to measure the effects of salvage logging on herbaceous species diversity; however, additional skills and techniques will be needed to detect differences in epiphytic lichens, bryophytes, and fungi diversity.

M. How does residual snag density affect wildlife, or, how much is enough?

Discussion:

There is no definitive answer to the question "how much is enough?" There are as many value-based dimensions to the question as technical aspects. Issues of risk tolerance (e.g., short-term risks versus long-term risks) and the desired balance among competing objectives play heavily in choosing among approaches.

It is clear that dead wood plays a critical role in providing wildlife habitat; however details concerning influences of quantity, characteristics, and spatial distribution of dead wood on wildlife after fire is less clear. The relationship between snag density and population response of wildlife is uncertain. Also, the effects of alternative spatial patterns (e.g., clumped vs. dispersed) are not known, although clumping snags may facilitate safer logging operations, as well as use by certain bird species like woodpeckers. It is well established that in general large diameter snags provide important resources to wildlife that are not provided by smaller snags. For example, cavities large enough for large vertebrates, such as the pileated woodpecker, can only be excavated from larger snags.

Numerous other issues should be considered. Snag creation and decomposition occur over multiple decades requiring a long-term view if the goal is to provide temporal connectivity until the next stand generates new snags. Snags provide ecological functions other than wildlife habitat (e.g., source populations of lichens), which may be a factor to consider when designating snags for retention. The surrounding landscape may provide some clues regarding locations for snag retention. It may be of value to concentrate snags in areas where there are few in the surrounding landscape or in areas where snags are more likely to survive high wind events or future fires.

There are a number of wildlife species that use snags: cavity-nesting birds, bats (especially snags with bark remaining), and spotted-owl prey species, such as flying squirrels and woodrats. Based on a general understanding of species' life history and habitat requirements, we expect that fire directly impacts flying squirrel and woodrat populations through mortality and habitat destruction. Secondary impacts are also likely due to reduction in fungi and lichen food resources. Abundant opportunities for nesting cavities will be available as these stands start to recover. Most wildlife populations will likely recover after pronounced short-term (5-10 years) impacts. In addition, some wildlife and plant species are expected to increase in post-fire and early successional forest habitats.

Science status:

Given the importance of snag-related issues, it is disconcerting how little is known. Although we can glean some information from studies of snags in clearcuts and studies in other geographic regions, post-fire snag studies have not been conducted in western Oregon. However, a number of important questions concerning wildlife use of snags following fire are amenable to a large-scale field study that could be implemented through post-fire salvage operations (see next section). Treatments that span a range of snag densities could be established and replicated across a landscape and monitored over the long term. Questions of snag dynamics and use could be addressed through such a study.

Summary:

It is clear that snags play an important role for wildlife following fire, but the question of how many snags should be retained to achieve wildlife goals is unclear. Although this question is ultimately one of policy, important technical and ecological questions remain unanswered. A large-scale field study could help answer these questions.

N. What considerations should guide reforestation decisions?

Discussion:

It is well understood how to re-establish trees on a site. For some sites, it may be more important to focus on tree survival rather than maximum stand growth. For example, lower planting densities and less intensive release and weeding operations may be appropriate when tree survival is the goal. Also, it is important to look at the future impact of early silvicultural treatments on fuel management. Clear goals for future stand structure and composition will help guide replanting and other silvicultural decisions. Currently, silvicultural regimes designed for survival and development of late-successional habitat in the frequent fire zones of southwestern Oregon are not well understood. There may be an inherent trade-off between fire-proofing stands and creating complex stand structures. Obtaining mature forest habitat may require passing through a developmental stage that is highly flammable.

Science status:

Although reforestation techniques for maximum stand growth and yield are well understood, efficient approaches for growing late-successional habitat in southwestern Oregon are not. In particular, methods of minimizing risk of stand loss through fire need to be developed and integrated with habitat goals. These questions are amenable to a field study. Relatively small plots (1-2 acres each) could be established with alternative reforestation densities, tree species, and release regimes implemented in both salvaged and unsalvaged areas.

Summary:

Where late-successional habitat is a primary objective, reforestation and silvicultural regimes may be best focused on tree survival. A relatively small-scale field study could effectively address silvicultural regime questions.

IV. Alternative field study designs

The science team and BLM managers and specialists discussed various ideas for experimental treatments that would help build knowledge for future EIS teams facing similar questions and issues. Key considerations include a clear set of questions to drive the design of an experiment and sufficient rigor in the design to produce reliable results.

A number of factors influence the rigor and reliability of field studies:

- Replication - It is important to reduce the role of chance occurrences by repeating the suite of study treatments several times across the landscape.
- Randomization - It is important to reduce the bias inherent in assigning specific treatments to specific sites. Random assignment of treatments accomplishes this need. The implication is that managers need to be willing to apply any of the treatments on any site.
- Controls - Study controls are essential so the existence of a treatment effect can be established. There are different types of controls, and this issue needs to be built into the design from the beginning.
- Treatment extremes - Treatment extremes on both ends of the spectrum are needed to demonstrate and frame outcomes.
- Spatial scale - The appropriate spatial scale of the study depends on the questions being addressed. For example, if you want to address wildlife issues, than an area large enough to measure wildlife response (i.e., home range size) needs to be included in the study. Furthermore, it is important to differentiate between local- and watershed-scale effects, and this may require a multiple-scale study design.
- Temporal scale - The scale of the questions being addressed will also dictate the temporal scale of the study. Long-term studies require thinking ahead to determine how treatments will be applied through time and requires a long-term commitment of these sites to the study.

The science team identified two primary areas for study that address high priority management questions related to post-fire management activities. The first study would address the question "how does salvage intensity influence wildlife and fuels?" The study would include four treatments; two that represent alternative approaches to meet management objectives and two that represent a more intensive extreme and an unsalvaged area. Treatment units would need to be at least 30 acres in size so that wildlife responses could be measured and four replications should be implemented.

A second study could address understory treatments. Specifically, it would address the question "how does planting , species composition, planting density and subsequent vegetation treatments influence reforestation and fuels?" This study would include two alternative planting densities, two planting species mixes, and two release regimes. Each set of treatments would be implemented in both salvaged and unsalvaged areas, and on both north-and south-facing slopes. Unplanted plots would need to be included for a control. Plot size could be much smaller, one to two acres in size, and replicated three to four times.

These general ideas are a starting point. Further discussion and clarification of the primary objectives are needed to integrate management and research interests and to fit the studies to the landscape.

V. Conclusions

The interaction among science team members and resource managers and specialists from the BLM Medford District has proven valuable from a number of perspectives. This report may help interdisciplinary teams sort high priority issues from more minor concerns, and it identifies key information gaps that field studies and monitoring activities could address. It is important to recognize that this report is also limited in a number of respects, including an absence of a thorough review of the literature, absence of any data or quantitative assessment of fire and management effects, and the restricted disciplinary expertise and experience of the science team members. The report is intended to apply only to southwestern Oregon and, even within that region, is most applicable to the types of sites found on the Butte Falls Resource Area.

The process has also proved beneficial by building relationships among managers and scientists, and by increasing the mutual understanding of science processes and management realities and needs. Managers involved in this process gained a better appreciation for the limitations of the current knowledge base and of the difficulties inherent in determining cause and effect. Scientists involved in the process have been exposed to a real-time management environment where decisions have to be made in the short term, with or without solid data. The outcomes of this report will hopefully point a way towards increased management-science collaboration through adaptive management processes where management questions are tested using the methods of science in an operational management program.

Appendix A

Science team members, affiliation, and discipline

December 2002 Science Team

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